2.0 Roadway Separation/Reinforcement

2.1 Paved Roads*

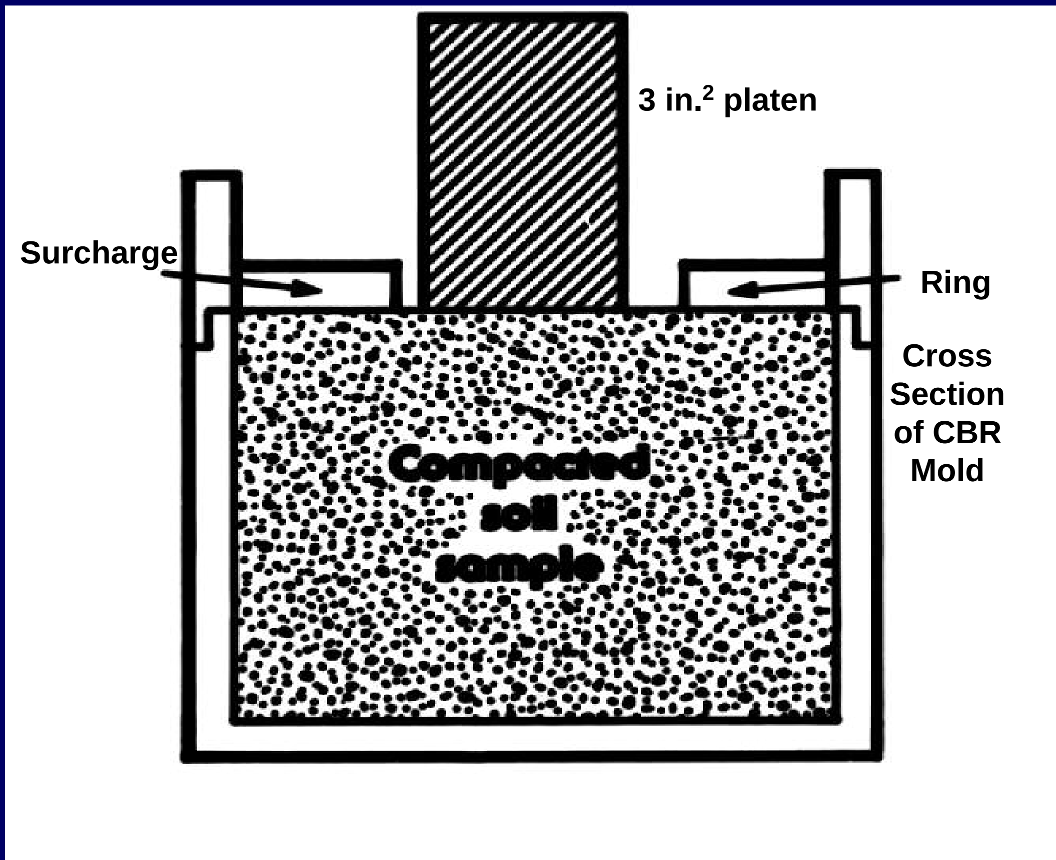
2.2 Unpaved Roads**

2.3 MESLs

2.4 Railroads

California Bearing Ratio (CBR) Test
(to assess strength of subgrade soil)

- **its mainly a laboratory test**
- **can be “unsoaked” or “soaked”**
- **needs representative sample**
- **based on penetration force in soil compared to standardized stone base**
- **can also be done in field**
- **ASTM D 1883 (lab); or D 4429 (field)**



$$CBR(\%) = \frac{\text{Force in Subgrade Soil}}{\text{Force in Stone Base}}(100)$$

Geotextile Function	CBR Value (%)	
	unsoaked or field	soaked
Separation[1]	≥ 8	≥ 3
Stabilization[2]	8-3	3-1
Reinforcement[3]	≤ 3	≤ 1

(1) As in paved roads
(2) Depends on traffic use and loads
(3) As in unpaved roads (also geogrids)

2.1 Paved Roads

2.1 Paved Roads - Separation

- **Geotextile placed on soil subgrade covered with granular base course and then paved**
- **Function is separation, i.e., no holes are acceptable**
- **Thus focus is on installation survivability**
- **Several design models available:**
  - **burst resistance**
  - **grab tensile strength resistance**
  - **puncture resistance**
  - **Impact (tear) resistance**
- **Burst model follows:**

Burst Resistance Design

$$FS = \frac{T_{allow}}{T_{reqd}}$$

$$= \frac{p_{test} d_{test}}{\left(\prod RF\right) p' d_v}$$

Example: If d_{test} = 30 mm, $d_v = 0.33 d_a$; ΠRF = 1.5; what is FS?

Solution:

$$FS = \frac{p_{test}\,30}{(1.5)p'(0.33\,d_a)}$$

$$= \frac{60\,p_{test}}{p' d_a}$$

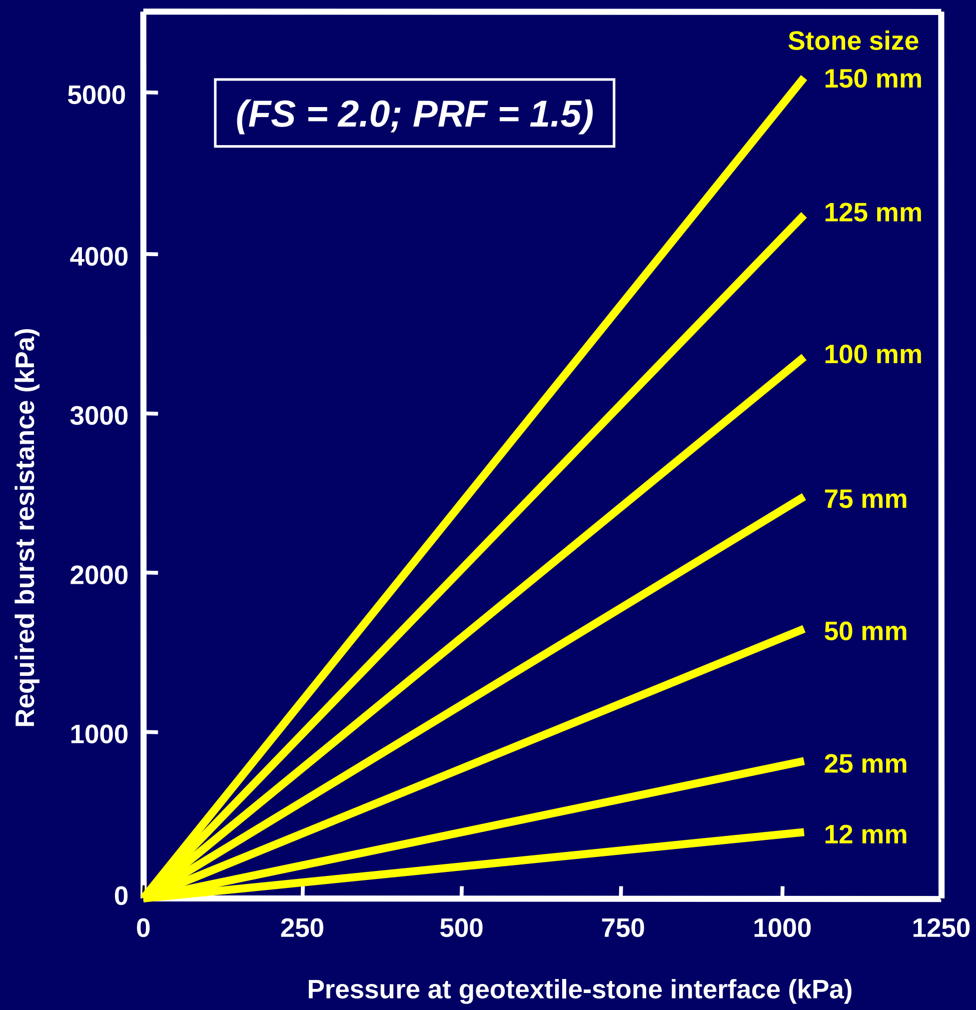
further: If p' = 700 kPa; p_{test} = 2000 kPa and d_a = 50 mm

$$FS = \frac{60\,(2000)}{(700)(50)}$$

$$= 3.5$$

or: make a design graph for a given FS, e.g., 2.0.

Example design graph for GT burst analysis



2.1 Paved Roads - Stone Containment*

- Geogrid (sometime geotextile) placed within granular base course
- Interlocking with base course to prevent lateral spreading is the function, i.e., lateral reinforcement
- Geogrid aperture size vis-à-vis base course size seems to be important
- High torsional rigidity may also be important
- Placement in lower half of base course appears best

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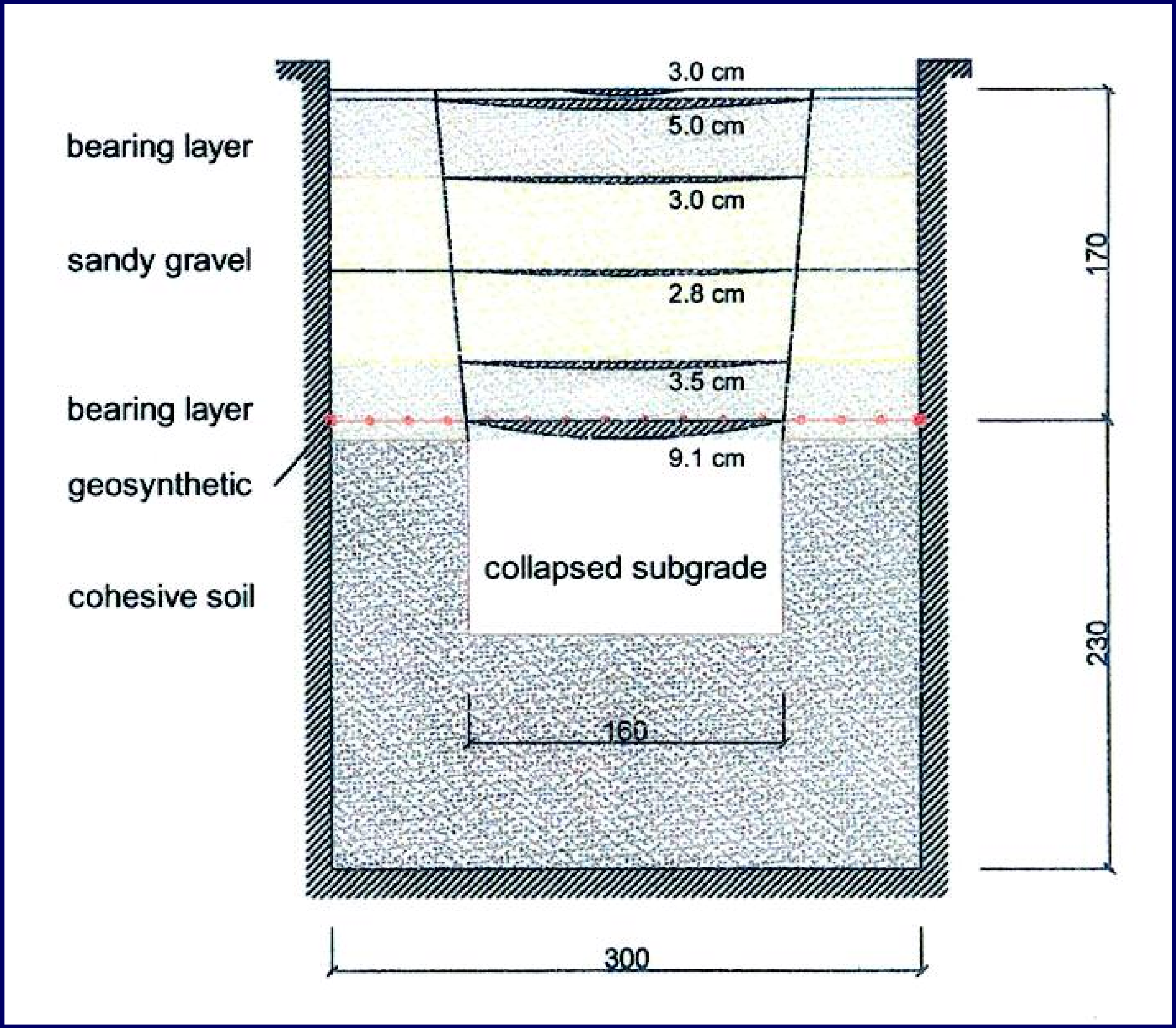
*Synthesis by Perkins & Ismeik, 1997 J. of G & G, Vol. 4, Geosynthetics Intl., is an excellent review

Reinforcement of Localized Depressions and Sinkholes

- identify cause of problem
- bracket lateral extent
- try to estimate depth
- try to estimate abruptness
- situation can be serious

Sinkhole Collapse Situation

Research on GG Reinforcement is Ongoing



2.2 Unpaved Roads

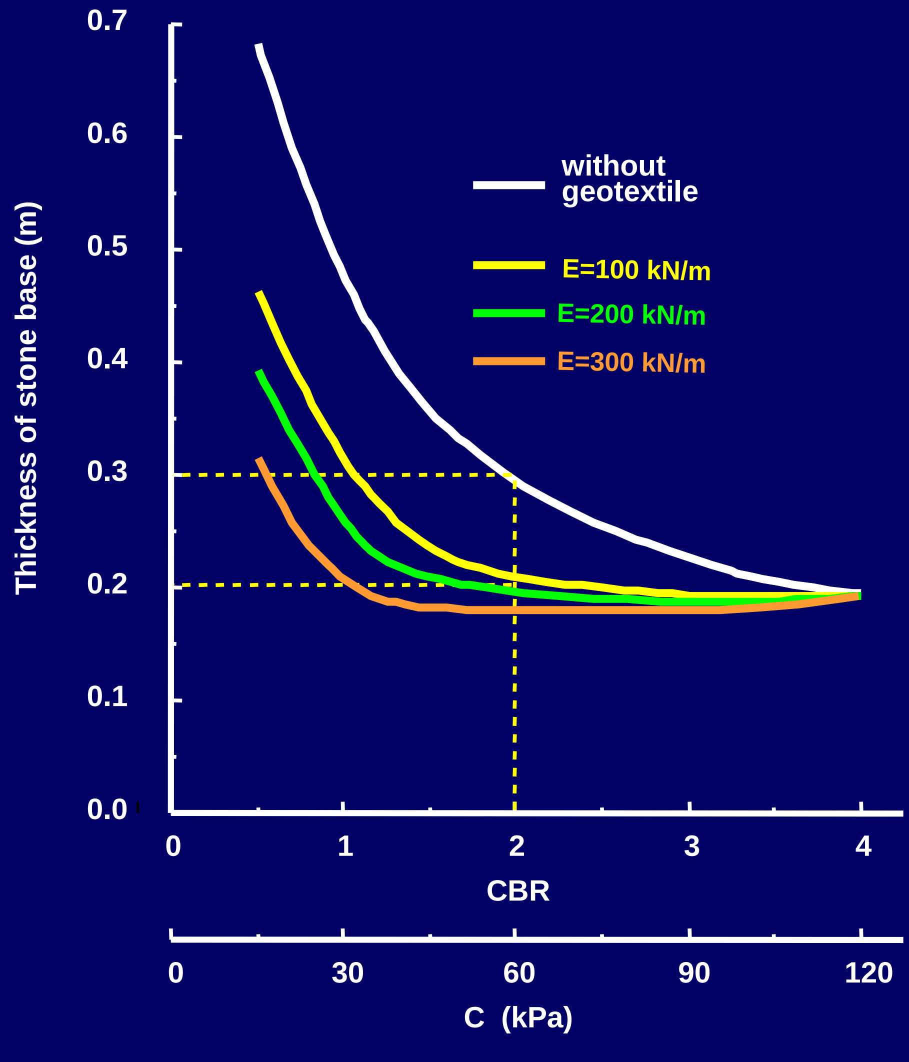
2.2 Unpaved Roads

- justification for GT or GG in paved roads is longer service life, while
- justification for GT or GG in unpaved roads is thinner stone base course
- soft soil conditions; $CBR_{us} \leq 3$; $CBR_{s} \leq 1$
- many manufacturers methods available - also computer codes

2.2 Unpaved Roads *(cont'd)*

- basic hypothesis is that failure mode goes from punching shear to general shear
- Giroud method is generic and based on the modulus of the GT or GG
- needs modulus from D4595 wide width test
- see next design example and cost analysis

Unpaved road design example



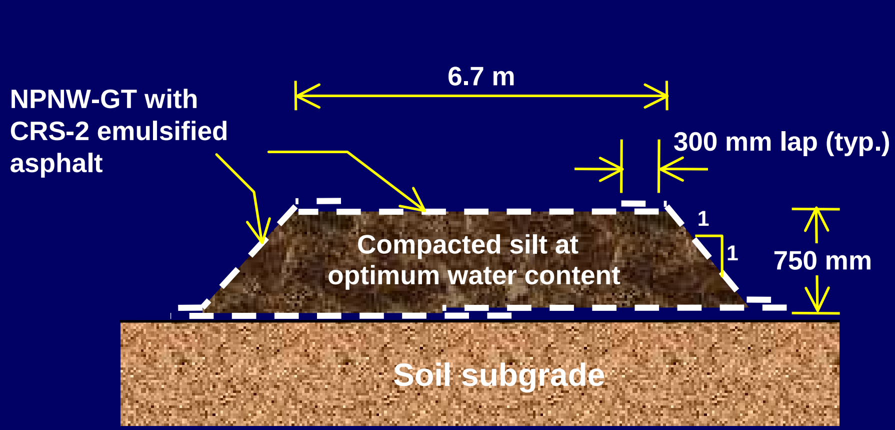
Economic analysis

Distance (km)	Aggregate Cost (dollars/kN)	Aggregate Cost (dollars/m^2-mm)	Aggregate Savings (dollars/m^2)	Geotextile Cost (dollars/m^2)	Geotextile Savings (dollars/m^2)
< 5	0.90	0.018	1.71	0.72	0.99
5-20	1.20	0.024	2.31	0.76	1.55
20-50	1.70	0.035	3.31	0.78	2.53
50-100	2.50	0.050	4.79	0.84	3.95
100-200	3.80	0.075	7.13	0.90	6.23

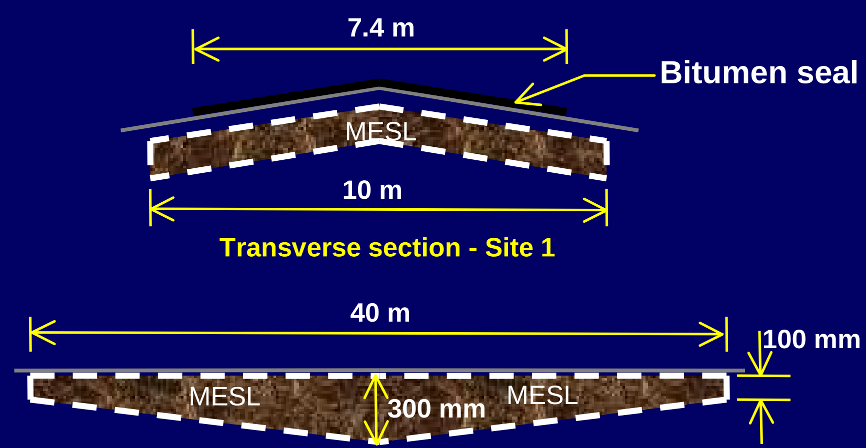
2.3 Membrane Encapsulated Soil Layers (MESLS)

- developed by Corps of Engineers Cold Regions Lab
- target soils are MLs and OLs which are moisture sensitive
- good bearing at optimum moisture; however too soft when wet, and too friable when dry
- optimum moisture is retained by encapsulating the soil with a bitumen impregnated GT
- needle punched nonwovens of high survivability properties are preferred

Various cross sections of MESLs



(a) Above-ground in cold regions
(after Smith and Pazsint)



(b) Below-ground in semiarid regions
(after Lawson and Ingles)

2.4 Railroads

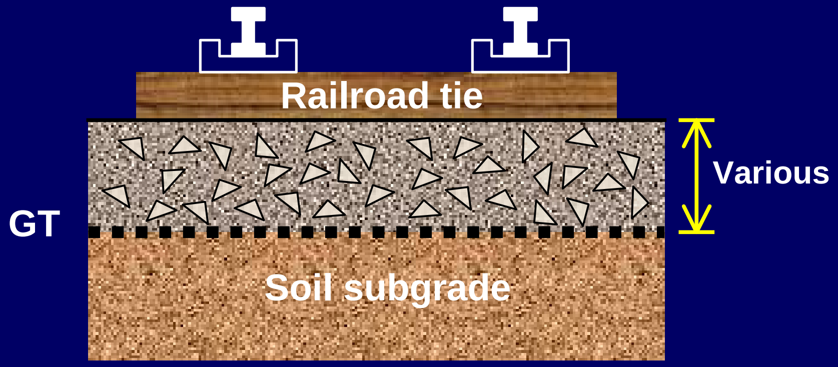
- GT functions are separation, lateral reinforcement, filtration
- GG function is lateral reinforcement
- survivability requirements are very high
- abrasion and puncture are critical
- stay as deep in the cross section as economically possible

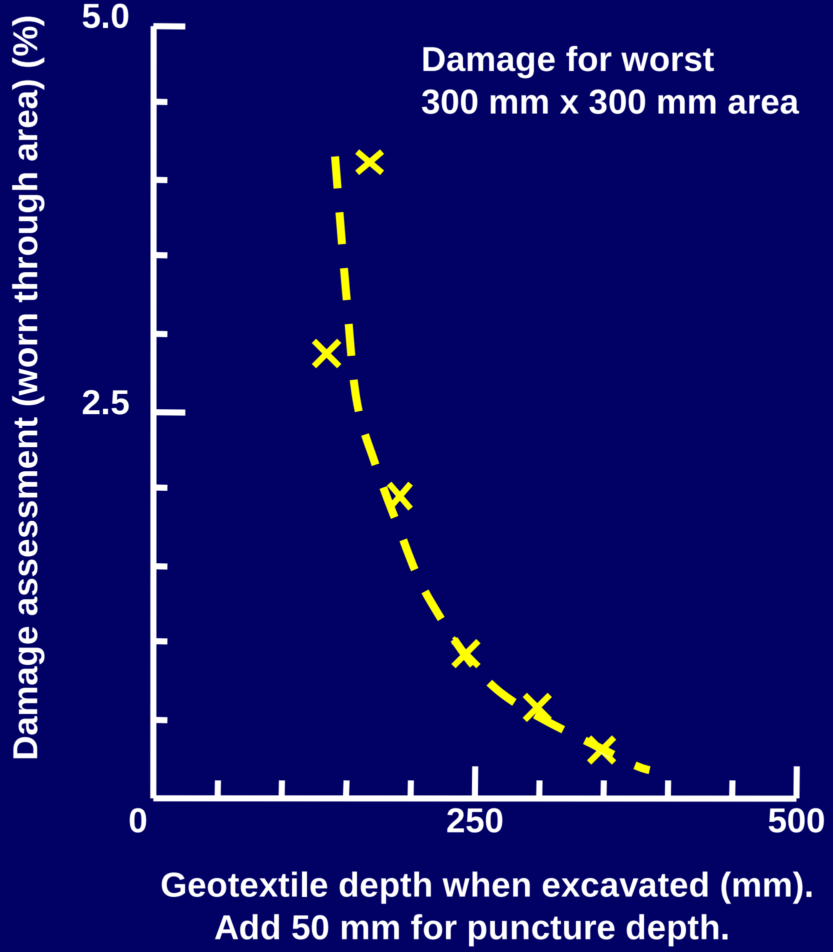
Railroads *(cont'd)*

Adequate Depth is Critical

- **installation can cause puncture**
- **dynamic loads can cause abrasion**
- **sufficient ballast must be above GT to avoid both**
- **many situations have occurred where this was <u>not</u> the case**

Observed GT abrasion damage as a function of depth beneath bottom of railroad tie





End of Section-2